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GB 1212867
GB 856784
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(54) Permanent single-point mooring system

(57) In a single-point mooring comprising a buoy 5 which is rotatable around a central shaft moored by lines to the sea bed and a rigid mooring arm 1 pivoted to the buoy, vertical motions of the buoy and arm are damped by damping members attached to each respectively. The damping members may comprise planar parts 46, 47 which are co-planar with pivot axes 32 and 4 as shown in Fig. 3 or lie at a small angle downwardly with regard to such a plane.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

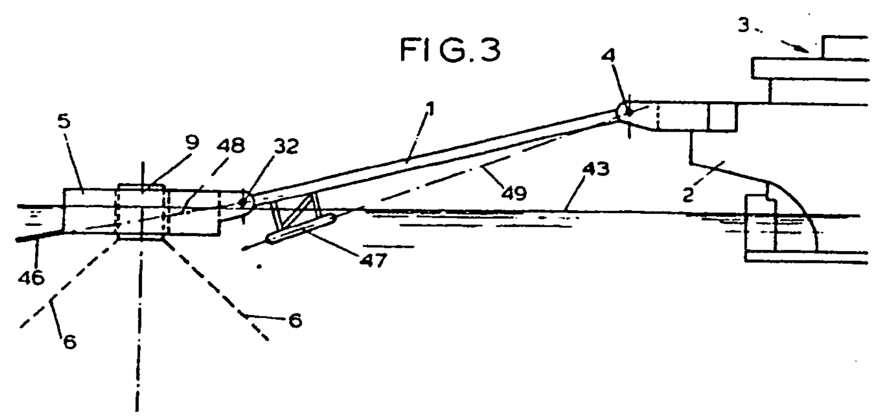

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FIG.1

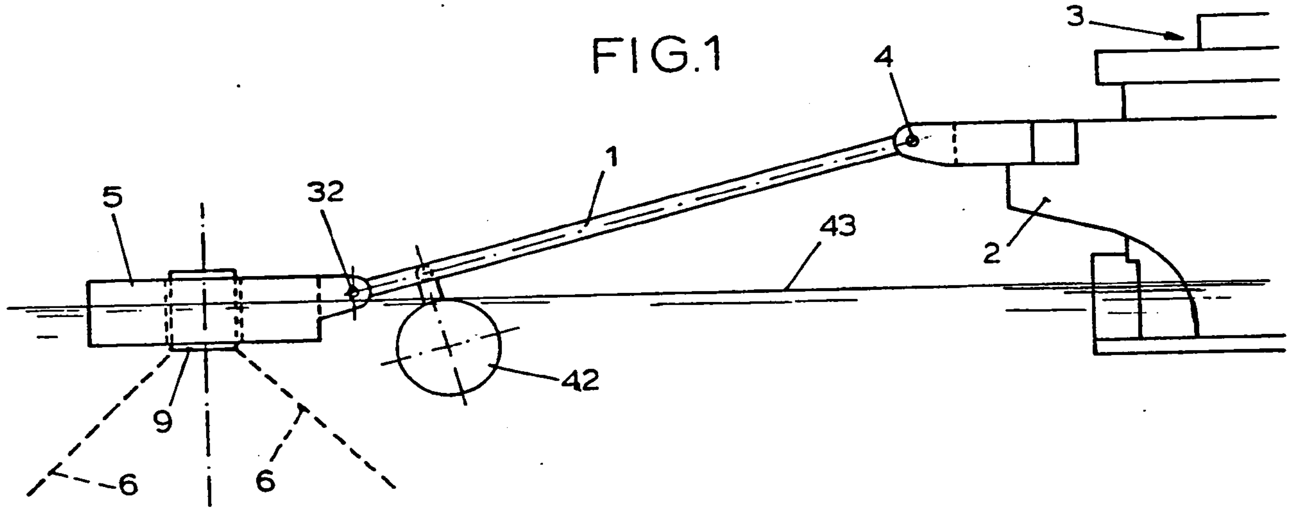


FIG.4

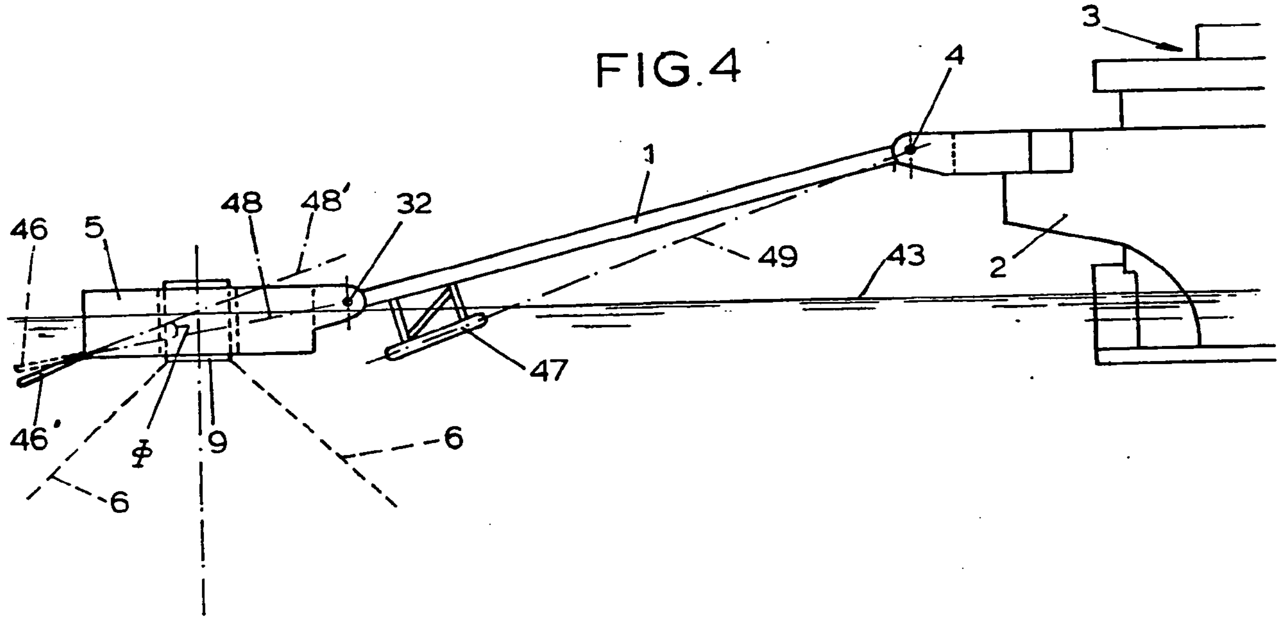


FIG.2

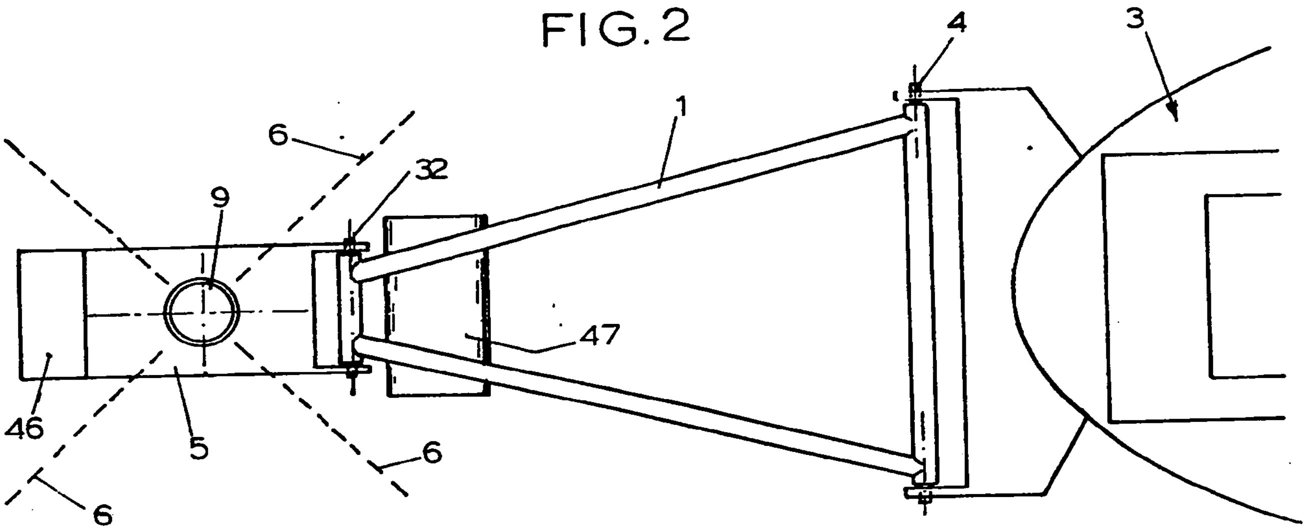
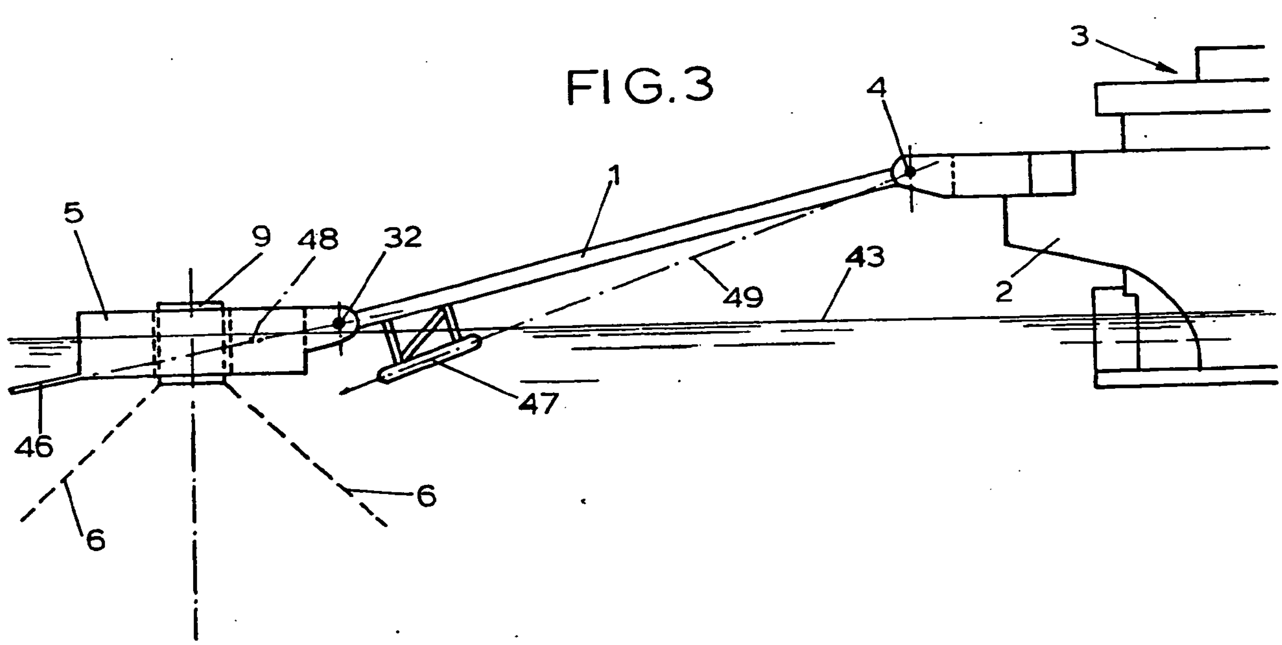


FIG.3



SPECIFICATION
Permanent single-point mooring system

The present invention is an improvement of the permanent single-point mooring (SPM) system disclosed in the parent application 44 435/78 filed on the 14th November 1978. That system relates to a permanent single-point mooring system for a floating unit which comprises a buoy anchored to the sea-bed with anchor points and catenary shaped anchor lines, which are connected to a central shaft located in the buoy around which the buoy — and the floating unit moored to the buoy — can rotate in a horizontal plane, the means for attaching the floating unit to the buoy being such that the floating unit may also move in a vertical plane so as to accommodate the relative motion between the buoy and the floating unit caused by wave action and loading condition of the floating unit, said floating unit attaching means being formed of a rigid connecting yoke which is attached at one end to the buoy and at the other to the floating unit and said floating unit attaching means also comprising flexible joints associated with the rigid yoke, two radial and one axial flexible joints allowing only for a horizontal hinge motion between buoy and yoke on one side and between yoke and floating unit on the other side of the yoke. A very flexible system is obtained, adapted for use in a body of water with great differences between low and high tide, if the buoy has a rectangular shape of which the length is considerably larger than its width and whereby the catenary shaped anchor chains are connected to a central shaft whose diameter size is small with respect to the width dimension of the buoy. In a preferred embodiment of the system concerned the means for flexible attachment of the yoke to the buoy are located above the water line at the short side of the rectangular buoy near deck level.

Accordingly a mooring system is obtained having a low roll resistance about the X—X axis, that means a greater instability, a high resistance against torsion and a high tipping resistance.

The parent application certainly works fine under normal weather conditions at sea. There are, however, areas at sea, which have to beat up against very severe weather conditions so that the system just disclosed cannot stand completely the pitching motions of the buoy and the yoke so that these motions may constitute a limiting factor on the applicability of the system.

Therefore an improvement is sought by increasing the damping of the system by adding skirts. Normally skirts would be placed on each side of the buoy and directly connected to the buoy, said skirts being in a horizontal plane. On account of interactions between rigid arm and buoy, such skirts do not give any appreciable improvement. It was found, however, that considerable improvement could be made if the rigid arm (yoke) had its own damping, making thus the connection point between yoke and buoy to a rather stable point, and to provide the buoy with a skirt system that would damp the pitch motions of the buoy around the hinge point between the rigid arm and the buoy.

Since skirts are most effective if they are moved perpendicular to the motion direction, the skirt attached to the rigid arm should be oriented, in principle, in the direction of its rotation point, which is the hinge connection between rigid arm and vessel.

A further improvement in the damping action of the skirts can be obtained if the permanent buoyancy tank, located underneath the rigid arm (or yoke) simultaneously acts as damping member and for that purpose is provided, at its sides, with fins.

On the other hand the damping member can be shaped as a flat member, a so-called skirt, of small thickness.

For the damping of the system parts (buoy; rigid arm) the distance to the pivot point is significant. Therefore location of the skirt on the front side of the buoy and as deeply as possible under water is most favourable, wherein the plane of the skirt or the extension of that plane must run through the pivot arm, in principle.

The correct position of the skirt is, still further, defined by an other phenomenon. An arriving wave or rolling waves, will tempt to lift the buoy, if it were, from below upwards. A skirt that is oriented downwardly will tempt to be pressed down by the wave. These two pressure forces can compensate each other, so that in practice the best position of the skirt is such that the plane of the skirt does not run completely through the pivot axis but forms a small angle downward with respect to the connection line to the pivot axis.

Owing to the features of the present invention the buoy can be held horizontal as much as possible which is essential in relation to the hose connection underneath the bottom of the buoy, since in that case the hose is suspended vertically excluding bending loads on the hose connections. This greatly improves and prolongates the life of the hoses which is extremely important.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which

fig. 1 illustrates an embodiment of the parent application;

fig. 2 shows a plane view and

fig. 3 an elevation view of a mooring system, damped in accordance with the invention; and

fig. 4 shows another orientation of damped skirt.

The mooring system shown in these figures is of the single-point mooring (SPM) type. A rigid arm 1 is connected on the one hand to the bow or the stern 2 of a storage vessel 3, on the other hand to a buoy 5 by maintenance-free bearings 4 and 32 resp., allowing the vessel 3, the rigid arm 1 and the buoy 5 to pitch relatively to each other. Anchor chains 6, piled to the sea-bed are used to hold the buoy in position. The rigid arm or yoke 1 is supported by a permanent buoyancy tank 42 located under the yoke 1 so that the buoy will not list under the weight of the yoke 1 and remains

level when the yoke is disconnected.

Yet, not all motions of the buoy are controlled in this manner. The system so far disclosed works excellent under non-severe weather conditions. If the conditions become severe the system cannot avoid that heavy pitching motions can occur, which should be damped.

In figs. 2 and 3 damping means 46 and 47 are provided resp. on the buoy 5 and also on the rigid arm 1. The flat skirtlike damping member 47 replaces the cylinder-shaped buoyancy tank 42 of fig. 1. It may be noted in fig. 3 that the plane of the buoy damping skirt, if extended, runs through the pivot axis 32; in cross-section according to line 48. Similarly the plane of the yoke skirt 47 runs through the pivot axis 4; in cross-section according to line 49.

In fig. 4 the buoy skirt 46 is shown in a second orientation 46′, after the skirt 46 has been rotated in an anti-clockwise direction over a small angle ϕ, which is the angle between the previous orientation direction 48 and the new direction 48′. The effect is a quietly floating buoy even under severe weather conditions. In principle it is indifferent which of the two damping skirts 46, 47 has the additional feature of being tilted extra over said small angle ϕ. However the provision of this extra feature to the buoy skirt 46 is to be preferred since such feature provided to the buoy skirt 46 has more effect than if it is provided to the yoke skirt 47.

CLAIMS

1. A permanent single-point mooring system for a floating unit which comprises a buoy anchored to the sea-bed with anchor points and catenary shaped anchor lines, which are connected to a central shaft located in the buoy around which the buoy — and the floating unit moored to the buoy — can rotate in a horizontal plane, the means for attaching the floating unit to the buoy being such that the floating unit may also move in a vertical plane so as to accommodate the relative motion between the buoy and the floating unit caused by wave action and loading condition of the floating unit, said floating unit attaching means being formed of a rigid connecting yoke which is attached at one end to the buoy and at the other to the floating unit and said floating unit attaching means also comprising flexible joints associated with the rigid yoke, two radial and one axial flexible joints allowing only for a horizontal hinge motion between buoy and yoke at one side and between yoke and floating unit at the other side of the yoke, characterized in that the buoy and the rigid arm (or yoke) are each individually provided with a damping member for damping pitching motions.

2. A single-point mooring system according to claim 1, characterized in that for damping pitching motions of the buoy the damping member is provided at the front side, that means at the end of the buoy (5) turned away from the mooring site for floating units (3).

3. A single-point mooring system according to claim 1, characterized in that for damping pitching motions of the rigid arm (or yoke 1) situated between buoy (5) and floating unit (3) the damping member is provided near the connection between the rigid arm (1) and the buoy (5).

4. A single-point mooring system according to claim 3, characterized in that the permanent buoyancy tank (42), located underneath the rigid arm (or yoke) simultaneously acts as damping member and for that purpose is provided, at its sides, with fins.

5. A single-point mooring system according to any of claims 1—3, characterized in that the damping member is shaped as a flat member, a so-called skirt, of small thickness.

6. A single point mooring system according to claim 5, characterized in that the main surface of the damping skirt is parallel to the plane running through the centre line of the skirt and the pivot axis of the system part to be damped.

7. A single-point mooring system according to claim 5, characterized in that the plane of the skirt does not run completely through the pivot axis but forms a small angle downward with respect to the connection line to the pivot axis.

8. A permanent single-point mooring arrangement for a floating unit constructed, arranged and adapted to operate substantially as herein described with reference to the accompanying drawings.

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